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Psychological Time: Interval Length Judgments and Subjective Passage of Time Judgments

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Introduction

1 Time is a crucial dimension of our perceived world (Buhusi & Meck, 2005). There is a vast amount of literature investigating the factors that distort time perception, with a focus on topics such as time management or time perspective taking (Grondin, 2010; Caruso, Gilbert, & Wilson, 2008; Zimbardo & Boyd, 1999). Such literature aims to discover strategies that can permit us to better manage our temporal behavior.

2 Time perception encompasses different subjective time experiences: (1) *interval length (duration) estimation*, and (2) *subjective passage of time judgments*, defined as the perceived speed of time passage (Block, 1990; Wearden, 2005).

Interval length (duration) estimates

3 This type of subjective time perception is the most frequently studied in the literature (Block, 1990) and it is defined as the subjective evaluation of duration length. In order to assess this perceptive experience, researchers use methods like verbal estimation, asking the participants to estimate, in minutes or/and seconds the length of a temporal interval (Block, 1990).

Methodological factors with relevance for interval length estimates

4 The influence of various factors on interval length judgments is considered to be contingent upon methodological factors, amongst which the study paradigm is of great importance (Block & Zakay, 1997). A crucial distinction in any study focused on time perception is that between: (1) the retrospective paradigm and (2) the prospective paradigm (Block & Zakay, 1997). Contemporary time researchers are unanimous that confusing these two is fatal to any proper progress in this field (Wearden, 2005).

5 The retrospective paradigm is defined by the fact that study participants are not aware in advance that they will have the task to estimate interval length; they are exposed to specific stimuli or events and then asked to estimate the duration of the time interval that contained those stimuli or events (Block, 1990).

6 The prospective paradigm is defined by the fact that the study participants know in advance that the task will involve estimating the length of a temporal interval, being aware that they will need to estimate the duration of a task or event, estimation called, for clarity, "experienced duration" (Block, 1990).

Factors that influence interval length estimates

7 As for the factors that affect interval length, research findings indicate that the cognitive load (how cognitively demanding a task is) is one of the most important variables that determine the interval length estimates.

8 In the retrospective paradigm, the more difficult the task is, the longer the temporal interval is estimated. In order to explain these results, researchers use memory models, which state that the amount of information (or contextual changes) encoded from one interval is used for making inferences about the elapsed time during that interval (Ornstein, 1969; Block & Reed, 1978).

9 On the other hand, contradictory to the results obtained in the retrospective paradigm, in the prospective paradigm, if the task is difficult, the temporal interval is estimated as shorter than it chronologically is. Researchers use attentional models for explaining the results in this paradigm. These models state that when the task is difficult, the cognitive resources are preferentially allocated for task related information processing and the person has less cognitive resources available to process the temporal information (Block & Zakay, 1997).

10 Zakay (1992) introduced the idea that there are other variables, aside from the task difficulty (or cognitive load), that can have an impact on the amount of attention allocated to temporal information. He suggested that attention to time increases whenever timing becomes important for adaptation to an event (for example, while facing a deadline). He defined the concept of *temporal relevance* as the "level of relevancy and importance of time dimension in a specific state required for the optimal adaptation to the external environment" (p.110), stating that when temporal relevance is high, the interval length is perceived as longer because we pay more attention to time.

11 However, it is not clear whether temporal relevance has the same impact on interval length estimates regardless of the task difficulty and it would be important to investigate the possible interaction effects between these two variables (task difficulty

and temporal relevance) on interval length estimates in order to understand the conditions in which temporal relevance affects temporal judgments.

Subjective passage of time judgments

12 Wearden (2005) described another specific type of subjective time experience, which he calls "passage of time judgments". In this type of temporal perception, the participants do not evaluate the length of an interval, but they evaluate perception of the speed with which time passes, or the perceived speed of time passage. This temporal experience is assessed by asking the participants to indicate, on a Likert scale, how quickly time seemed to pass during a task. Wearden (2005) describes a study which shows that the subjective passage of time judgments and interval length judgments are separate temporal experiences. In this study, one group of participants watched 9 minutes of the film "Armageddon" and another group of participants waited for 9 minutes in a simulated "waiting room" condition. At the end of the 9 minutes they were asked to judge how quickly time seemed to pass (*subjective passage of time judgments*). The participants in the "Armaggedon" group rated the passage of time as faster than normal, and those in the "waiting room" judged time as passing slower than normal. Next, they had the task to read a novel for 10 minutes and after this interval elapsed, they were asked to estimate the length of the time interval spent either watching the movie or waiting (*retrospective interval length judgments*). The waiting condition was estimated as being shorter that the movie condition. The period of time seemed to drag for the participants in the waiting condition, although retrospectively it was judged as being short, because they stored less information from that interval. These results showed that although an interval can be retrospectively underestimated, time can be judged as passing slow during that interval, and the two temporal experiences (interval length judgments and subjective passage of time judgments) are distinct.

13 However, in the study performed by Wearden (2005), the two mentioned temporal experiences were not assessed at the same time and, in order to clarify the relationship between them, it would be important to investigate them under the same methodological conditions.

Factors that influence subjective passage of time judgments

14 Studies on variables affecting subjective passage of time have suggested that this type of judgment is affected by the hedonic value of the task. More specifically, if people perceive a task or event as being pleasant, they perceive time as passing quickly. Conversely, during a boring task, time is perceived as passing slowly (Watt, 1991; Sucala et al., 2010). While these findings match the naïve theory "time flies when you are having fun", the cognitive mechanisms that can explain them are still unclear. Except for the few mentioned study, this particular type of time experience has rarely been investigated (Sucala et al., 2010), although it contributes to our time management behaviors.

15 Since the subjective passage of time judgments and interval length judgments have rarely been investigated in the same study, under the same methodological conditions, it is difficult to infer whether they are affected by the same variables or the nature of

their relationship. The previous attempts to clarify the factors that affect subjective passage of time judgments have used the retrospective paradigm, and it would be important to also understand the factors that impact the subjective passage of time judgments under the prospective paradigm as well.

Overview of the present study

16 One objective of this study is to investigate, in the prospective paradigm, the impact of temporal relevance and task difficulty on both interval length judgments and subjective passage of time judgments. Also, another objective was to clarify the possible interaction effects between these two variables (task difficulty and temporal relevance) in their impact on interval length judgments and subjective passage of time judgments. We also wanted to investigate if interval length judgments and subjective passage of time judgments are related.

17 Another objective of this study was to investigate the impact hedonic value of the task on both interval length judgments and subjective passage of time judgments.

Method

Participants

18 78 undergraduate students participated in the experiment in exchange for course credit. 71 of them were women and 7 of them were men. The mean age was 21.88, *SD*=3.80. The study had IRB approval and informed consent was obtained prior to participation.

Design and Procedure

19 A two-factor design was used. The first factor is task difficulty, which had two levels - shallow/structural processing and deep/semantic processing (Craik & Lockhart, 1972). In the shallow/structural level group, the participants were asked to read a text and identify all the words that started with the letter S. The text was printed, written in Times New Roman font, sized 12. In the deep/semantic level group, participants were told to read the same text, to identify all the words that started with the letter S, and to find a synonym for them (Dixon & Eye, 1984).

20 The second factor is temporal relevance, which had two levels – high temporal relevance and low temporal relevance. In the high temporal relevance group the participants were told that they have a time limit and they should work as fast as possible, starting and stopping the task when they heard the START and STOP words, respectively. In the low temporal relevance group, participants were simply told to start when they heard the word START.

21 Participants were randomly assigned to the four experimental conditions. After telling them the instructions mentioned above, all participants were told that they would have to estimate the length of the task after completion. All the participants were told to stop working after 4 minutes (240 seconds). Duration was measured using a digital stopwatch.

Measures

22 *Interval length judgments.* After the participants heard the word STOP, they were asked to make verbal estimates (in minutes and seconds) for the temporal length of the task.

23 Following standard practice, in order to evaluate the direction of the temporal distortion, estimated times were transformed into measures representing Directional Errors (Khan, Sharma & Dixit, 2006). When participants are required to give verbal estimates of various interval durations, the standard procedure is to convert the data into ratio scores by dividing the estimated duration by the actual duration (Brown, 1985). In the transformed data set, a value of less than 1 represents a temporal duration underestimate, whereas a value greater than 1 represents a temporal overestimate. A directional error of 1 represents an accurate estimation (Wahl & Sieg, 1980; Pintea, 2010).

24 *Subjective passage of time judgments.* The participants were also asked to indicate how quickly time seemed to pass during the task (Wearden, 2005). We used a 5-point Likert scale where 1= "time flew", 3= "normal", and 5="time dragged". Lower ratings indicated an accelerated subjective time passage and higher ratings indicated a slower subjective time passage.

25 *Ratings of hedonic interest.* Ratings of hedonic interest were also assessed using a 5 point Likert scale where 1="boring", 3="medium", and 5="very interesting" (Sackett et al., 2009).

Results

26 Basic descriptive statistics of prospective interval length estimates, subjective passage of time judgments, and ratings of hedonic interest are presented in Table 1.

Table 1 Mean (and Standard Deviations) for Interval length judgments (Directional error), for Subjective passage of time judgments and for Ratings of interest as a function of Temporal relevance and Task difficulty

Task Difficulty	"Shallow	processing"	"Deep	processing"
Temporal relevance	Low (n=27)	High (n=15)	Low (n=17)	High (n=19)
Interval length judgments (Directional error)	.84 (.11)	1.08 (.17)	.81 (.12)	.86 (.16)
Subjective passage	3.66 (.48)	4.40 (.50)	3.41 (.71)	3.52 (.51)
Ratings of interest	3.03 (.89)	3.00 (.53)	3.17 (.80)	3.21 (.63)

27 An analysis of variance (ANOVA) was computed for each dependent variable: transformed prospective interval length estimates, subjective time passage judgments, and ratings of hedonic interest.

28 *Prospective interval length estimates.* The main effect of Temporal relevance was significant $F(1, 78)=18.78$, $p<.001$, $d=.98$, indicating that in the High temporal relevance condition, participants perceived the interval length as longer. The effect of the Level of processing was also significant $F(1, 78)=15.20$, $p<.001$, $d=.88$, indicating that in the Shallow processing level condition, participants evaluated the temporal interval as being longer than in the Deep processing level condition. The Temporal relevance × Level of processing interaction was significant, $F(2, 78)=7.71$, $p=.007$, $d=.62$. For the difficult task there was no difference between the interval length estimates given by the participants in the low temporal relevance group and the participants in the high temporal relevance group ($p>.05$). However, for the simple task, participants in the high temporal relevance group gave significantly longer interval length estimates than the participants in the low temporal relevance group, $t(42)=5.29$, $p<.001$, $d=1.67$ (see Table 1).

29 *Subjective time passage judgments*. Temporal relevance had a significant effect on subjective time passage judgments $F(1, 78)=11.01$, $p<.001$, $d=.75$, indicating that in the high temporal relevance condition, participants perceived time as passing more slowly. The effect of the level of processing was also significant $F(1, 78)=19.50$, $p<.001$, $d=1.00$, indicating that in the Shallow processing level condition, participants perceived time as passing slower than in the Deep processing level condition. The Temporal relevance × Level of processing interaction was significant, $F(2, 78)=5.85$, $p<.001$, $d=.54$. For the difficult task, there was no difference between the high temporal relevance and the low temporal relevance groups. However, for the simple task, when participants were aware of the time passage (high temporal relevance) they perceived time as passing significantly slower than when they were not aware of the time passage (low temporal awareness group), $t(42)=4.64$, $p<.001$, $d=1.5$(see Table 1).

30 *Ratings of hedonic interest.* Overall mean ratings of hedonic interest were near the midpoint of the 5-point Likert scale. The ratings of hedonic interest did not differ significantly as a function of either task difficulty or temporal relevance (all p's$>.05$). The ratings of interest did not significantly correlate with either interval length estimates or with subjective passage of time judgments (all p's$>.05$) (see Table 1).

31 Furthermore, we investigated the relationship between the prospective duration estimates and the subjective time passage judgments. We found a significant correlation between these two variables ($r=.33$, $p=.010$), indicating that a longer prospective estimate is associated with a slower perceived time passage.

Discussion

32 The results of the present study indicate that when the time dimension becomes relevant (e.g., when having a time limit for completing a specific task) we allocate more of our attentional resources to temporal information, and give longer interval length estimates. If during an interval we pay close attention to time, constantly monitoring the time cues, we judge the interval to be longer. We also found that simpler tasks tend to be perceived as longer. These results are consistent with the attentional models of time, which state that prospective duration timing depends on attention demanding processes that occur concurrently with the processing of nontemporal information (Thomas & Weaver, 1975; Zakay & Block, 1997). Therefore, the more attentional demanding the task that fills the interval is, the shorter the estimates for the length of

that interval will be. These models view interval length perception as a direct function of the amount of attention allocated for processing time related information (Zakay, 1992).

33 As researchers suggested (Zakay, 1992) the attention to time increases not only when the task that fills the interval is easy, but also when time becomes relevant (like having a deadline imposed for completing the task). Further investigating the interaction effect between task difficulty and temporal relevance, this study brings an important finding. When the task is difficult, the interval length estimates are shorter than for simple tasks, regardless of the level of temporal relevance. When the task is more demanding, although time might be relevant, as in the situation of having a deadline, the attentional resources are preferentially allocated for solving the task. However, when the task is simple, being aware of time passage (high temporal relevance) leads to temporal overestimates (the interval length is judged as being longer than it chronologically is) because, as Zakay (1992) suggested, when time becomes relevant, the perceptual system becomes sensitive to any internal or external time cues, and the non-demanding task allows more resources to be allocated for temporal processing.

34 A major finding of this study is that subjective time passage judgments seem to be affected by the same factors as interval length estimation. In other words, results indicate that both temporal relevance and level of task difficulty have a significant impact on subjective time passage judgments. Time is perceived as passing slowly when we are aware of its passage and when we are involved in solving tasks that are not difficult. It also appears that that the slowest time passage occurs when the person becomes aware of a time limit for resolving a simple task.

35 Based on the results, it seems possible that these two temporal experiences, interval length estimates and subjective time passage judgments, as assessed in the prospective paradigm, rely on the same attentional mechanisms. This idea is further supported by the significant correlation found between these two variables, showing that a longer interval length estimate is associated with a slower perceived time passage.

36 We did not find that interest/boredom is related to either subjective passage of time judgments or interval length judgments, but it is possible that the results are due to the task we selected, which triggered mean ratings of interest near the midpoint of the Likert scale in all experimental conditions.

37 This study is the first to specifically investigate, under the same paradigm, the factors that affect both interval length judgments and subjective passage of time judgments. The study adds empirical data that could clarify the cognitive mechanisms on which the two temporal experiences are based on.

38 The present study is not without limitations. Only undergraduate students participated in this study and most of the participants were women. Therefore, these results may not generalize to men, or individuals of different age groups.

39 Future studies could also take in consideration the effect of affective factors while investigating the role of temporal relevance on time perception since it is possible that, in real life situation, facing a deadline for a specific task can trigger affective factors that might have relevance for both interval length estimates and for subjective time passage judgments.

40 To our knowledge, this study is the first to investigate both interval length estimates and subjective time passage judgments under the same methodological conditions. The

results have both theoretical and practical implications that are likely to benefit the field, as well as individuals' efforts to better manage temporal resources. If we want to control our temporal behavior in order to obtain a better management of our time resources it is crucial to know which variables predict the way we perceive time.

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ABSTRACTS

Time perception encompasses different subjective time experiences, like: (1) interval length (duration) estimation, and (2) subjective passage of time judgments, defined as the perceived speed of time passage.
This study aims to investigate and clarify the impact of task difficulty, temporal relevance and hedonic interest on both interval length judgments and subjective passage of time judgments. Another aim of the study is to investigate whether interval length judgments and subjective passage of time judgments are related.
The results of the present study indicate that task difficulty and temporal relevance have a significant impact on interval length judgments. In terms of their interaction, the results show that when the task is simple, a high temporal relevance leads to interval length overestimates. Another major finding of this study was that subjective time passage judgments seem to be affected by the same factors as interval length estimation. In other words, results indicate that both temporal relevance and level of task difficulty have a significant impact on subjective time passage judgments. Also, we found a significant correlation between interval length judgments and subjective passage of time judgments, indicating that a longer interval estimate is associated with a slower perceived time passage.
The results of the present study are discussed in terms of the attentional models of time perception.

La perception du temps comprend : (1) la longueur perçue de l'intervalle, et (2) la vitesse perçue du temps (le passage subjectif du temps).
Cette étude a pour objectif d'examiner et de clarifier l'impact de trois variables (la difficulté de la tâche, la pression du temps et l'intérêt sur la tache) sur la longueur perçue de l'intervalle et sur la vitesse perçue du temps. Un autre but de l'étude est d'examiner si la longueur de l'intervalle et

la vitesse perçue du temps sont liées.
Les résultats de la présente étude indiquent que la difficulté de la tâche et la pression du temps ont un impact significatif sur la longueur perçue de l'intervalle. En ce qui concerne leur interaction, les résultats montrent que lorsque la tâche est simple, une grande pression temporelle conduit à une surestimation de la longueur de l'intervalle. Un autre résultat important de cette étude est que la vitesse perçue du temps est affectée par les mêmes variables que la longueur perçue de l'intervalle. Les résultats indiquent que la pression du temps et la difficulté de la tâche ont un impact significatif sur la vitesse perçue du temps. Nous avons trouvé une corrélation significative entre la longueur perçue de l'intervalle et la vitesse perçue du temps.
Les résultats de cette étude sont discutés en termes de modèles d'attention de la perception du temps.

INDEX

Keywords: attentional models of time perception, interval length judgments, subjective passage of time judgments
Mots-clés: longueur perçue de l'intervalle, modèles d'attention de la perception du temps, vitesse perçue du temps

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